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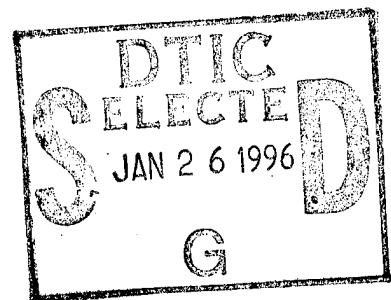Defence   nationale

DATA FUSION AND CORRELATION TECHNIQUES TESTBED (DFACTT):
A COMMAND AND CONTROL INFORMATION SYSTEM FOR LAND ELECTRONIC WARFARE (U)

by

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ABSTRACT

Electronic Warfare is a land combat function. To be effective on the modern battlefield, Land EW requires an integrated Command and Control Information System (CCIS). The EW CCIS must automate the tasking of EW assets, sensor data collection, and reporting of threat warnings and tactical Signals Intelligence (SIGINT) to the battlefield commander. Automation of the command and control function has changed the Electronic Warfare process, resulting in a continuously evolving EW CCIS requirement specific to the Canadian Forces. The Data Fusion And Correlation Techniques Testbed (DFACTT) is being developed at Defence Research Establishment Ottawa using an evolutionary prototyping approach to determine and define the CCIS and tactical SIGINT analysis requirements of the Land Force's EW squadron. This report describes the status of the DFACTT project as of September 1995.

RÉSUMÉ

La Guerre Électronique (GÉ) relève des forces de combat terrestres. Un système intégrant les fonctions de Combat, de Contrôle et les Systèmes d'Information (CCSI) est essentiel à l'efficacité de la GÉ terrestre dans un champ de bataille moderne. Les fonctions de CCSI de la GÉ doivent automatiser la distribution des tâches à l'équipement de GÉ, la collecte des données pas les capteurs et assurer la transmission, au commandant du champ de bataille, des avertissements de menace et les renseignements tactiques sur les signaux de SIGINT. L'automatisation des fonctions de commande et de contrôle a modifié la façon de faire la GÉ. Il en résulte une évolution constante des besoins des forces Canadiennes pour les fonctions de CCSI pour la GÉ. Le Concept de prototype évolutif est utilisé au CRDO pour le développement du prototype d'évaluation des techniques de fusion et de corrélation des données (désigné par l'acronyme anglais DFACTT) pour définir et déterminer les besoins d'analyse tactique de SIGINT et les fonctions de CCSI nécessaires à l'escadron de GÉ des forces terrestres. Ce rapport fait le point sur les accomplissements du projet DFACTT jusqu' à septembre 1995.

EXECUTIVE SUMMARY

Land Electronic Warfare requires an automated and integrated Command and Control Information System (CCIS) to control EW sensors, collect data, and to electronically communicate the tactical Signals Intelligence (SIGINT) product to higher formations to be fused into the overall intelligence picture. The Data Fusion And Correlation Techniques Testbed (DFACTT) is being developed at Defence Research Establishment Ottawa to investigate automated CCIS and SIGINT analysis processes for land Electronic Warfare. The aim is to automate the collection, correlation and fusion of EW and intelligence data to provide near real-time enemy situation assessment and immediate threat warning to the battlefield commander. The system has been developed using an evolutionary "user-in-the-loop" prototyping approach and has undergone five years of exhaustive field trials with the Canadian Army EW Squadron. In 1995, DFACTT software was used to develop a Computerized Electronic Warfare Operation Centre for 2 (EW) Squadron of the 1st Canadian Division Headquarters and Signal Regiment.

DFACTT automates the functions of the Electronic Warfare Operation Centre and is comprised of multiple EW Analysis workstations and Search and Intercept workstations. DFACTT also provides workstations for Radio Direction Finding system control, and a complete EW CCIS to automate the command and reporting process of the EW squadron and passage of tactical SIGINT to higher level Intelligence cells. An EW Battlefield Simulator has been developed along with DFACTT to be used to test new EW analysis algorithms in DFACTT at DREO. It will also provide a garrison training tool for the EW squadron.

DFACTT has been interfaced with the Advanced Concept Tactical Information Fusion (ACTIF) system produced by Defence Research Establishment Valcartier (DREV) as part of the CRAD project Katimavik. The ACTIF has been developed for the Division and Brigade Intelligence Collection and Analysis Centre (ICAC). The interconnection of DFACTT with ACTIF allows the EW intelligence data to be fused with other reports to produce the ICAC's all-source intelligence estimate of the battlefield situation. The DFACTT and ACTIF systems have been successfully trialed with the EW squadron and Division ICAC during ABCA Exercise Northern Lights at CFB Kingston in June 1994, Command-Post Exercise Rite-Complex at CFB Valcartier in May 1995, and Exercise Katimavik `95 at CFB Kingston in June 1995. Future work under project Katimavik will continue to automate and improve the Intelligence/EW process for the Canadian Army.

The knowledge gained through DFACTT has been incorporated by DLR into the SOR for the EW Control and Analysis Centre (EWCAC) to be fielded with the EW squadron by 1998 under project L2066. Future research includes the fusion of new ESM sensor data, the use of knowledge-based systems to provide advanced analysis and decision aids, and further automation of the command and control process. The DFACTT and EW Battlefield Simulator will form the basis of an EW Automation ADM for Land Tactical EW Equipment Project L1246. This ADM will be used to produce an advanced EWCAC in the 2005 time-frame.

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1. INTRODUCTION

Land Electronic Warfare produces tactical Signals Intelligence (SIGINT) and threat-warnings which, if timely, can influence the outcome of the battle. Automation is required for the EW/Intelligence cycle to stay inside the ever-narrowing window of the commander's opportunity to respond to and impact battlefield situations. Land EW requires an automated and integrated Command and Control Information System (CCIS) to control EW sensors, collect data, and to electronically communicate the tactical SIGINT product to higher formations to be fused into the overall intelligence picture. As automation is introduced into the EW process, the process itself changes resulting in an evolving CCIS requirement.

The Data Fusion And Correlation Techniques Testbed (DFACTT) is being developed at Defence Research Establishment Ottawa to investigate automated CCIS and SIGINT analysis processes for land Electronic Warfare. The aim is to automate the collection, correlation and fusion of EW and intelligence data to provide near real-time enemy situation assessment and immediate threat warning to the battlefield commander. To accomplish this, the DFACTT employs integrated command, control, and communication functions to automate the complete EW process. DFACTT integrates EW sensors, such as radio direction finding and intercept systems with an automated CCIS. Data communications between EW detachments deployed across the battlefield is achieved using existing VHF Combat Net Radio equipment fielded by the Canadian Forces.

DFACTT automates the EW process of the Land Force EW squadron. It can automatically collect, correlate, and store EW and intelligence data in its object-oriented database. Information is automatically displayed as NATO standard icons overlaid on a digital map. The EW analyst can access database information directly from the map icons and from multi-media browsers. The system also provides automated sensor control, digital intercept recording/playback, communication traffic and network analysis, unit tracking, EW mission planning, battlefield assessment, and automated report generation and message handling. The system has been developed using an evolutionary "user-in-the-loop" prototyping approach and has undergone five years of exhaustive field trials with the Canadian Army EW Squadron.

DFACTT software was used in 1995 by Software Kinetics Limited to build a Computerized Electronic Warfare Operation Centre (CEWOC) for 2 (EW) Squadron of the 1st Canadian Division Headquarters and Signal Regiment. DFACTT functionality has helped define the Statement of Operational Requirements (SOR) and Functional Requirements Specification (FRS) for the EW Control and Analysis Centre (EWCAC), a CCIS for the land force EW squadron, to be fielded under project L2066, Land Tactical Electronic Warfare Improvement (LTEWI). DFACTT will also serve as the primary research platform to support the automated analysis component of project D6479, Land EW Automation and Sensors (LEWAS). LEWAS is the R&D project to address future land EW requirements by producing Advanced Development Models (ADM) for new EW systems to be fielded under capital project L1246, Land Tactical EW Equipment, in the post 2005 time-frame.

2. DFACTT DEVELOPMENT APPROACH

The Data Fusion And Correlation Techniques Testbed (DFACTT) was established in 1990 at Defence Research Establishment Ottawa to develop data fusion algorithms for land Electronic Warfare. Because the end-user was small and well defined, 2 (EW) Squadron of the 1st Canadian Division Headquarters and Signal Regiment (1 CDHSR), it was possible to focus research on the specific needs of the land force EW unit.

It was immediately obvious that any form of automated analysis would first require automation of the command and control functions of the EW squadron. The sensors deployed with the EW squadron were capable of overwhelming the EW analysts, who were using manual processing techniques. However, these sensor systems were under-utilized because taskings and sensor data were transferred by voice over VHF Combat Net Radio (CNR) or passed on hand-written reports. Previous attempts to field an automated analysis and C^2 system with the squadron were unsuccessful. These attempts failed because the detailed requirements of an automated EW command and control system for the Canadian EW squadron were not, and could not, be known. These failed attempts involved purchasing off-the-shelf, off-shore systems and fitting them into the squadron's operations.

A different approach was used in developing DFACTT. The first and most important step was to closely involve the end-users, the personnel of 2 EW squadron, in the research and development process. The next was to use a system development approach that permitted changes to be made quickly, easily, and frequently. This required software tools that supported rapid prototyping and provided advanced technologies for developing new data fusion algorithms, which is the primary purpose of DFACTT. The third element of the DFACTT development methodology was to validate the system in realistic environments with real equipment and study the system's operation and collect user feedback. This required frequent trials with 2 EW squadron during field exercises. The result was an ongoing iterative development cycle that continuously defined, fulfilled, and redefined the system requirements as new technologies became available and higher degrees of automation were introduced into the squadron. Tailoring the system's functionality to the evolving requirements of the end-users has resulted in a very high level of user acceptance, a critical factor in the system's effectiveness.

2.1 User-in-the-Loop Prototyping

DFACTT has been used to define the Statement of Operational Requirements for EWCAC. This was achieved by first producing a fully functional CCIS and EW analysis system through close end-user involvement in an iterative development process. Current DFACTT functionality represents the composite input of over one hundred EW intelligence analysts, communication research operators, and signals officers of the Canadian Forces. The operation of each DFACTT component has been tailored to the specialized equipment and doctrine of the

Canadian Land Force EW squadron. It also encompasses the effects of automation introduced by DFACTT on the operations of the EW squadron. After five years of system evolution and continuous trials, the automation provided by DFACTT has changed the command and control process of the EW squadron. This would not be possible without the ongoing cooperation, support, and participation of the squadron.

It is extremely difficult to define, in advance, the detailed requirements of an automated CCIS. This is especially true if the end-users cannot accurately describe their own manual processes. The first step in defining the requirements of a CCIS is to identify the process to be automated through human factors engineering. This is often attempted using process modelling techniques based only on published doctrine and standard operating procedures. The human factors engineering approach used in DFACTT focuses on the development of a full-function prototype system, with the user in-the-loop, to validate concepts and provide immediate feedback on all aspects of the CCIS model.

Since before 1990, personnel from the EW squadron have been closely involved in the evolution of DFACTT. DFACTT is comprised of a number of workstations for EW analysis, communications intercept, DF sensor control, data communications, and command and control. These workstations have provided squadron personnel with fully operational hands-on prototypes for trial and evaluation. Users have been able to describe what they like and dislike about the system and, most importantly, provide suggestions for further improvements to their operations. These concepts have been incorporated into the subsequent versions of these workstations and again trialed with the squadron. Concepts that proved useful were maintained and developed further, while ineffective functions were either changed or discontinued in later versions of the system. DFACTT has been continuously on trial with 2 EW squadron since April 1992 when it was installed into squadron vehicles for CF Exercise RV' 92[1]. Continuous user feedback and participation by research personnel, including contractors, in squadron field exercises has been necessary to support this research and development strategy.

All aspects of the DFACTT system have been tailored to meet the requirements of 2 EW squadron 1 CDHSR. This not only includes the requirements that existed at the beginning of the DFACTT project, but also new requirements that have resulted from automation of the EW process provided by DFACTT. This includes all Graphical User Interfaces (GUI), database structure, utilization of squadron communication equipment, integration of EW intercept and Direction Finding (DF) sensors, and automation of the EW command and control process. It would not have been possible to define these requirements without user involvement throughout the project. As new sensors, new communications, new threats, new missions, and new levels of automation are introduced, the EW process of the squadron will continue to evolve, as will the requirements for an EW CCIS. Ongoing research, closely involving the end-users, is required to continue to determine and fulfil these requirements.

2.2 Object-Oriented Design

DFACTT software is written in the object-oriented programming language Smalltalk. The DFACTT development system is a client/server network of SUN SPARC and Intel 486/Pentium workstations. Software is developed using ENVY[1]/Developer, a multi-user Smalltalk application development environment and code management system produced by Object Technology International (OTI) of Ottawa. The ENVY tools provided by OTI have enabled the DFACTT developers to rapidly create and integrate new functionality into the system. Object-oriented programming has permitted a significant amount of code reuse in the design and development of new functions, tremendously reducing the cycle-time and cost of the evolutionary development process.

Smalltalk was chosen as the development language for a number of reasons. Initial research in the late 1980's indicated that the functions to be investigated, data fusion, intelligence analysis, and command and control, best suited an object-oriented paradigm[2]. At the time, Smalltalk was one of the few object-oriented programming languages available. Even today, Smalltalk is still the most mature and advanced object-oriented language in the world. It continues to grow in popularity, even in comparison with C++, and is being used by many organizations for developing large mission-critical systems[3]. During the late 1980's DREO had developed a core of expertise in system development using Smalltalk as part of the Advanced Modular ESM Processor (AMEP) research project. The AMEP work and Smalltalk are now being used to develop the new CANEWS 2 Radar ESM system to be used for the mid-life upgrade of the Canadian Patrol Frigates. This expertise was leveraged to produce the initial versions of DFACTT. Smalltalk has since proved to be extremely effective in supporting the evolutionary prototyping and development methodology used by DFACTT, as attested to by the success of the project in determining and defining the operational requirements a CCIS for the EW squadron.

2.3 Sustainable Evolutionary Development

The primary mission of DFACTT is to investigate and develop data fusion algorithms for the analysis of land EW sensor data in the post 2000 time frame. Even though DFACTT has assisted in defining the SOR for EWCAC under project L2066, it must still serve as the primary research platform to support the automated analysis component of project D6479, the R&D project to produce an ADM for the future EW CCIS and analysis systems to be fielded under capital project L1246 in 2005. This requires that the development of the testbed applications be sustainable in the long term.

DFACTT was started in 1990 using Smalltalk and ENVY/Developer and has progressed over the last five years using the same development approach. There have been over a dozen

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[1]ENVY is a registered trademark of Object Technology International

versions of various DFACTT applications over this five years of evolution, with at least one major revision each year. The current version of DFACTT includes nine different types of workstations that are comprised of approximately 40 applications, 500 classes, and 7000 methods containing over 100,000 lines of Smalltalk code, not including the base Smalltalk class libraries. Such a development strategy would not be possible using conventional software engineering methodologies such as the waterfall model dictated by MIL-STD-2167A.

The success of this continuous evolutionary development strategy is due not only to the skills of the development team from Software Kinetics Limited, but in a large part to the ENVY tools used. The current version of ENVY supports the development of platform independent Smalltalk code. ENVY provides a seamless mapping of all operating system (OS) and graphical user interface (GUI) calls from the Smalltalk applications to the native OS and windowing system of most major platforms. These platforms currently include SunOS®, Solaris®, X-Windows/Motif on the SPARC platform; MS-Windows®, IBM OS/2®, Windows-NT® on the PC platform; Macintosh ®, embedded VME using VxWorks®, and many others. The Smalltalk OS and GUI API-level interfaces are fully POSIX and X-Windows/Motif compliant, regardless of the actual target platform. This will ensure that all existing Smalltalk code can be used and reused throughout the evolution of DFACTT, even as new hardware platforms and operating systems are adopted. This will also enable DFACTT to maintain compliance with the evolving Global Command and Control System (GCCS) Common Operating Environment (COE) standards. With the rapid rate of change of computer technologies, this seamless portability is essential to any sustainable long-term research and development effort.

3. DFACTT WORKSTATIONS

The DFACTT is comprised of a number of workstations that, together, automate the EW process of the Canadian Army's EW squadron. The functionality of these workstations has been determined through years of research into the EW squadron's doctrine and standard operating procedures as practised by the squadron's personnel in the field. It includes the integration of sensor and communications systems fielded with the squadron, the production of tactical SIGINT and threat warnings, and the command, control, and reporting process required to support a land force or joint force formation on the battlefield. It also encompasses the effects of automation on all of the above. The following is a brief description of the DFACTT workstations developed for the various detachments of the EW squadron shown in Figure 1.

3.1 Electronic Warfare Operation Centre

The primary components of DFACTT have been designed to automate the functions of the squadron's Electronic Warfare Operation Centre (EWOC) detachment. The EWOC complex includes an EW Analyst vehicle, a Tactical Communications Analysis System (TCAS) vehicle, and a radio communications vehicle. This detachment has been equipped with a system called

the Computerized Electronic Warfare Operation Centre (CEWOC) using a version of the DFACTT software. The Analyst vehicle is equipped with two EW analyst workstations, a junior and a senior position, and a Duty Officer workstation. The TCAS is equipped with three intercept workstations, one Search Intercept Supervisor (SIS) workstation, and a Computerized Audio Record Playback (CARP) system. The radio vehicle is equipped with a communications gateway that sends and receives messages over Combat Net Radio (CNR). All CEWOC vehicles are connected with a fibre-optic Ethernet LAN. The following is a description of the CEWOC workstations.
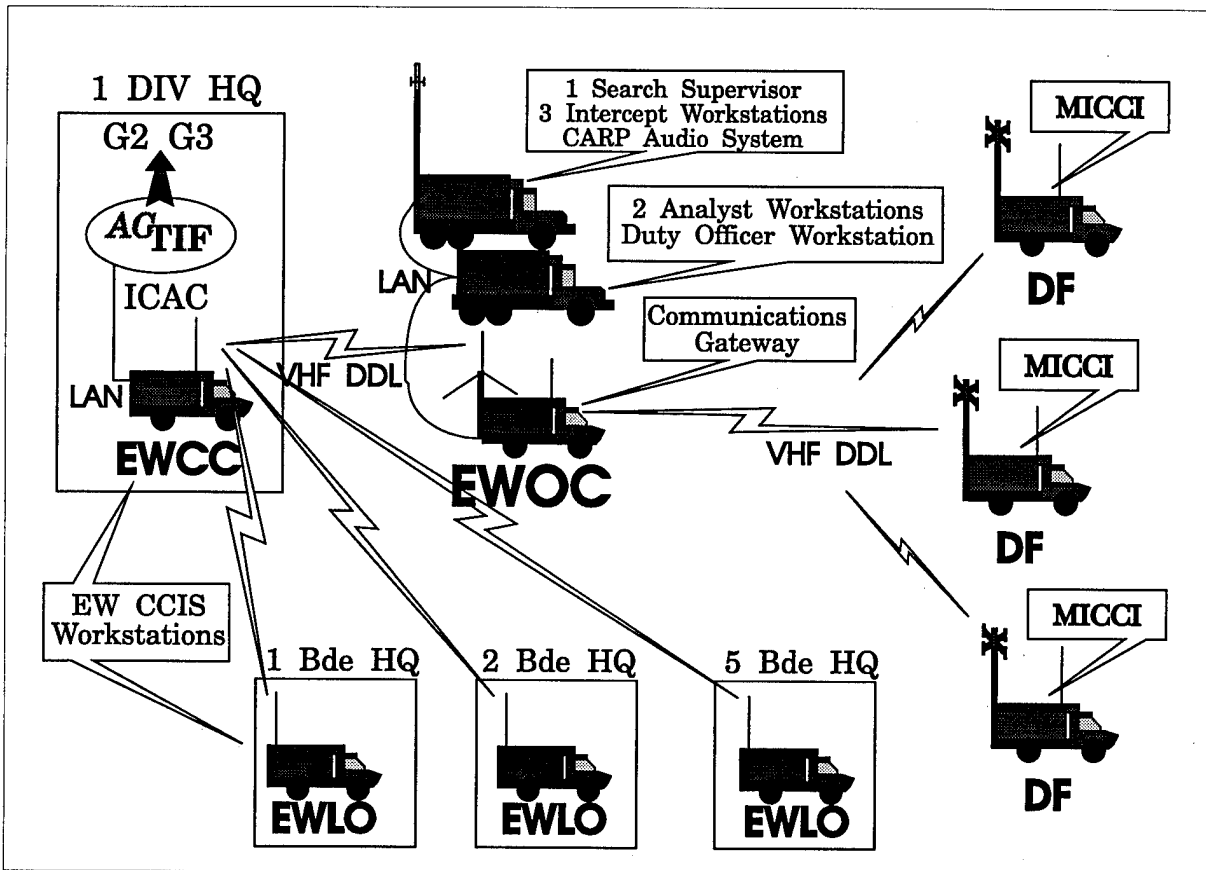

Figure 1 DFACTT/CEWOC Workstations for 2 (EW) Squadron 1 CDHSR.

3.2 EW Analysis

The EW analysis function is performed by two intelligence analysts, a junior analyst with the rank of Corporal or Master Corporal, and a senior analyst with the rank of Sergeant. The workstations for both analysts are connected via an Ethernet LAN and employ separate databases. All incoming sensor data, both DF and intercepts, is automatically replicated in both databases, as are reports and taskings. The senior and junior analysts are provided various mechanisms for sharing data, including overlays, situation hypotheses, and Order Of Battle

information. The senior analyst has the responsibility of making the situation assessment to be reported.

The EW analyst application uses an object-oriented Tactical Database that automates the reception, storage, and display of all data. All incoming data is classified, sorted, and processed as an object and then correlated with existing data objects in the Tactical Database. A global notification mechanism automatically displays data objects to the user in the ESM Browser and Tactical Map. The ESM Browser, shown in Figure 2, provides a textual representation of all objects in the Tactical Database. These objects include DF fixes and clusters, intercept gists, communication emitters, military units, and their communications networks and formation hierarchy. Objects can be referenced or sorted by any parameter of the object, such as frequency, time, location, identity, network, etc. The ESM Browser can also correlate objects by their parameters, such as correlating an intercept gist with a DF Fix by time and frequency, or an enemy unit with a gist by callsign. All analysis and reporting can be performed from the ESM Browser, but it is normally used in conjunction with the Tactical Map display.
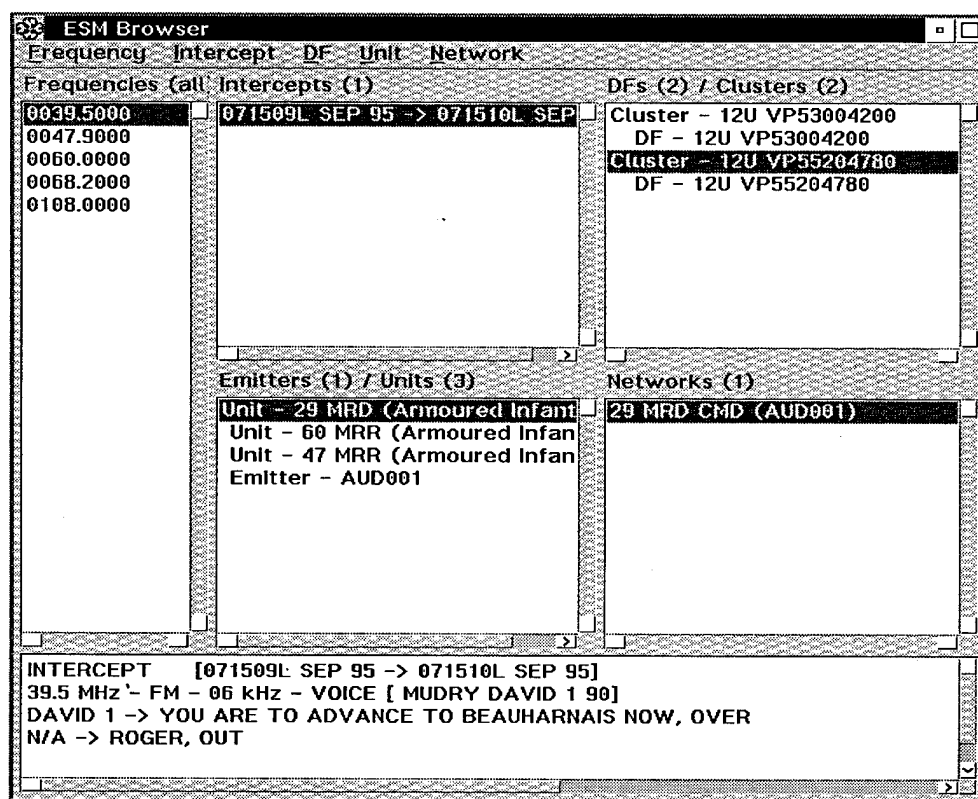

Figure 2 EW Analyst ESM Browser to the Tactical Database.

The Tactical Database uses the Tactical Map, shown in Figure 3, to automatically display any data object that has a geographic location. The DFACTT Tactical Map does not use static bit-mapped forms to overlay data on top of the digital map background. The operation of the

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Tactical Map can more accurately be described as a geospatial window into the object-oriented Tactical Database that underlays a digital raster map background. Any object with a known geographic location, such as a DF fix, is automatically displayed in the Tactical Map window, if the window encompassed the object's location. When the user selects an object on the Tactical Map with the mouse the object displays a brief description of itself in the bottom window pane. An object displayed in the Tactical Map window can be cross-referenced with its textual representation in the ESM Browser, and vice versa, from the object's pop-up menu. The pop-up menu functions available for a selected object are specific to the type of object selected and its present state in the database. Functions that operate on more than one selected object are invoked from the Tactical Map's background pop-up and pull-down menus.
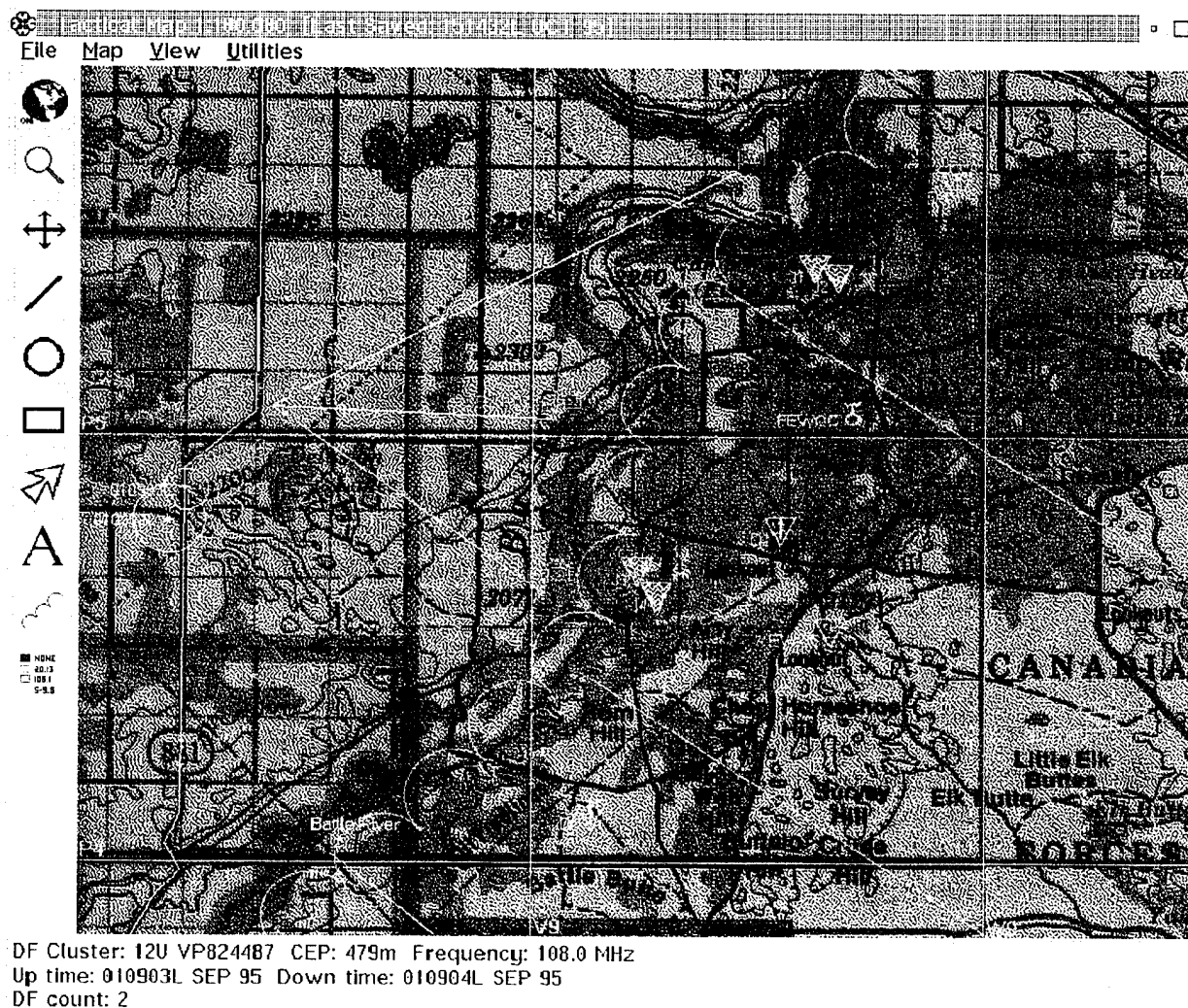

DF Cluster: 12U VP824487 CEP: 479m Frequency: 108.0 MHz
Up time: 010903L SEP 95 Down time: 010904L SEP 95
DF count: 2

Figure 3 EW Analyst Tactical Map.

The Tactical Map uses scanned paper or ARC Digital Raster Graphics (ADRG) map

data in grey-scale or colour for background display. The map window can be displayed at scales from 1:25,000 to 1:1,000,000. If map data is loaded for a given scale within the bounds of the map window it is automatically displayed, otherwise a black background is used. The Tactical Map provides its own UTM grid whether a map background is loaded or not. Because the EW sensor data and unit symbols are colour-coded, the users have found working with a grey-scale map or the black background most effective. The Tactical Map also uses Digital Terrain Elevation Data (DTED) for line of sight, path profile, and radio propagation path loss calculations for sensor coverage estimation. The functions for accessing both ADRG and DTED data are based on software tools provided by D Geo Ops. Because the EW analyst primarily uses the Tactical Map to view spatial data (military units, tracks, sensor data, etc.), a full-function Geographic Information System (GIS) is not required. This has allowed DFACTT to be developed without being tied to a commercial GIS.

Both analyst workstations are also equipped with multi-media tools for replaying and analysing communications intercepts provided by the TCAS. The ORBAT Browser, shown in Figure 4, provides an interactive graphical display of potential opposing force Order Of Battle (ORBAT) database information. The analyst can also graphically view the formation hierarchy and radio networks produced through analysis and compare them to the doctrinal ORBAT and Electronic Order Of Battle (EOB) of the opposing force. The analysts have other browsers that integrate functions such as intercept and DF tasking, report preparation, message logging, and local E-mail.
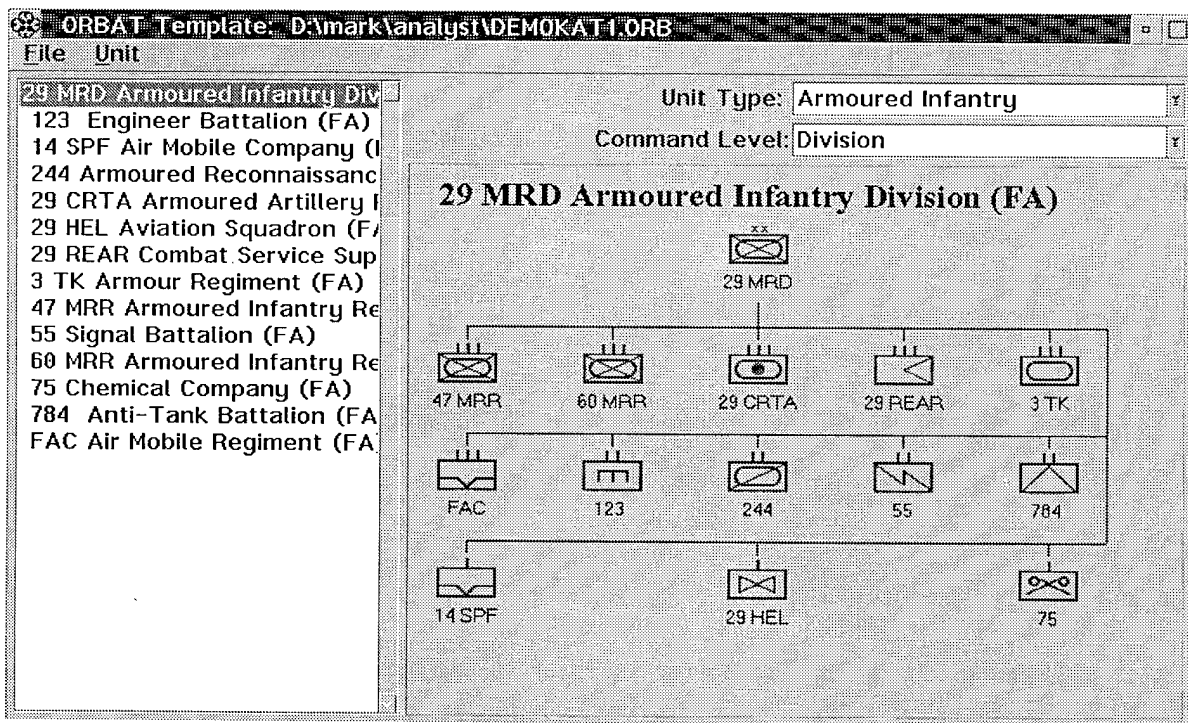

Figure 4 EW Analyst and CCIS ORBAT Browser.

The Senior EW Analyst workstation includes additional tools for combining EW assessments into a single intelligence estimate. The final intelligence assessment can be viewed using the Battlefield Assessment Map, which displays objects in the Assessment Database in the same manner as the Tactical Map and Database. The Assessment Map has the added feature of being able to replay events over time. This is useful for analysis of the battlefield situation over time and as a briefing tool for shift-handover.

The assessment of any unit in the Tactical Database or Assessment Database can be reported automatically to the EW Coordination Centre (EWCC) at the supported formation headquarters. The analyst selects the unit symbol on the map or browser, and creates a Tactical Report (TACREP) from the unit's pop-up menu. The system automatically fills in all pertinent information about the unit including its identity, location, time, communication networks, formation hierarchy, DF fixes, intercept gists, etc. This ASCII text report is then forwarded to the Duty Officer (normally a Warrant Officer) to be approved and released, with a single click of the mouse. The TACREP is transferred from the Duty Officer workstation over the fibre-optic LAN to the communication gateway in the radio vehicle. It is then automatically sent over VHF Combat Net Radio in a 600 bps burst transmission to the EWCC.

3.3 Search and Intercept

The other main component of the EWOC complex is the TCAS. The CEWOC system provides three intercept workstations and one Search Intercept Supervisor (SIS) workstation connected to the EWOC LAN. The intercept workstation automates the control of the V/UHF intercept receivers, provides digital recording and playback of audio intercepts, and entry and logging of gist reports using the Intercept Gist Browser shown Figure 5.
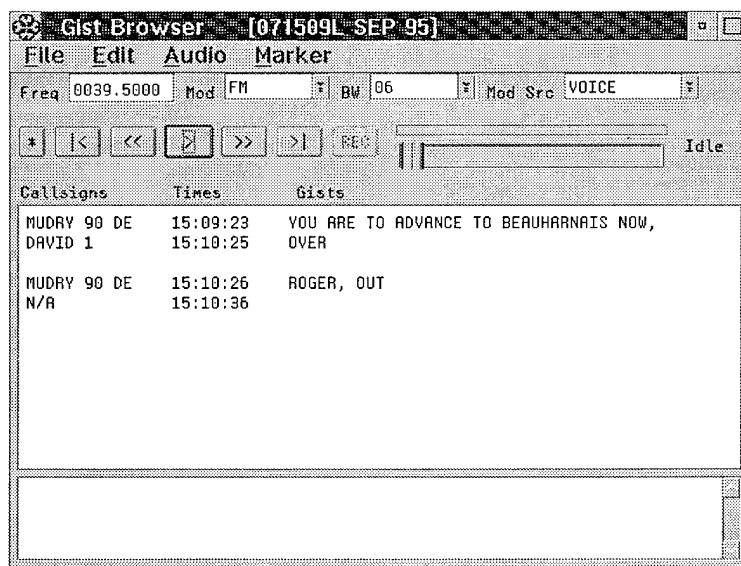

Figure 5 Intercept Gist Browser.

The SIS workstation automates the search, detection, and monitoring of radio transmissions using the Rapid Acquisition Spectral Processor (RASP), using the real-time Spectrum Browser shown in Figure 6. The SIS is responsible for tasking the intercept operators and for releasing gists and radio traffic data to the EW analysts. The Computerized Audio Record Playback (CARP) connects all intercept and SIS intercept receivers and audio panels to a central matrix switch and A/D/A converters. All TCAS positions can record/playback/monitor receivers in the TCAS via commands over the LAN to the CARP. The EW analysts can also replay recorded audio files from the intercept gists in the ESM Browser.
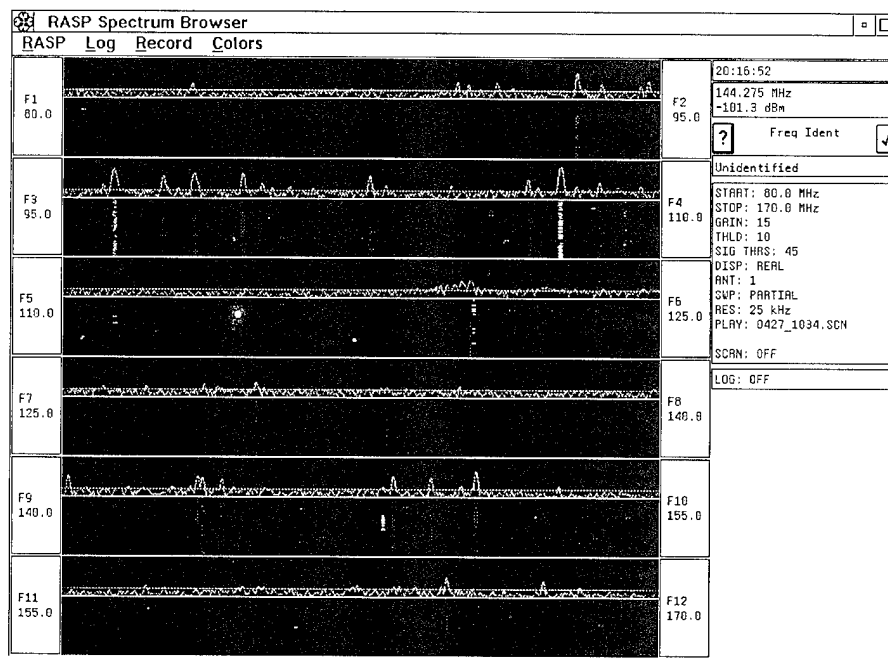

Figure 6 SIS RASP Spectrum Browser.

3.4 Radio Direction Finding

The Direction Finding (DF) system currently used by 2 EW squadron, called MANTIS, is a man-portable unit that has no indigenous command and control system. As part of the DFACTT project, an automated system called MANTIS Integrated Communications and Control Interface (MICCI) was developed to provide a seamless command, control, and communications interface between the MANTIS DF detachments and the EWOC. MICCI automatically processes and executes incoming tasks from the EWOC and returns DF data, using formatted text reports, over Combat Net Radio (CNR). The DF reports received at the EWOC are seamlessly and automatically processed by the EW analyst workstations and input into the Tactical Database. The DF report consists of the location estimates with circular error probability (CEP), called a fix, of target emitters. The EW Analyst station automatically

displays these fixes with their CEPs on the Tactical Map using a colour coding scheme assigned by the analyst for each radio frequency tasked. The analyst can further cluster related DF fixes together and correlate them with the gist of the radio transmission, if it was intercepted. Automation of the DF C^2 link and seamless processing of the DF data has had a significant impact on the operation of 2 EW Squadron and has greatly increased the timeliness of the tactical SIGINT product.

3.5 EW CCIS

A prototype Electronic Warfare Command and Control Information System (EW CCIS) workstation has been developed for the command and liaison detachments of the EW squadron, including the EWCC and EW Liaison Officer (EWLO) detachments. These CCIS workstations are capable of sending, receiving, and processing formatted text messages over tactical communications systems, including Combat Net Radio (CNR). The EW CCIS can automatically create objects represented by the information in the TACREPs sent from the EWOC, store them in a database, and display them on a Tactical Map. The CCIS uses a Tactical SIGINT Browser to display and access all reported information on the opposing force, including unit identities, radio networks, formation hierarchy, location history, and the source TACREPs. Units on the map are linked to the SIGINT Browser in the same manner as the EW analyst's Tactical Map and ESM Browser. The CCIS maintains a list of all TACREPs associated with each unit in its database. The system automatically parses and correlates incoming TACREPs with existing unit objects and updates the unit's identity, status, location, formation, networks, etc. The EWOC can send the same TACREP to the EWCC and all EWLO detachments in the same burst transmission, providing all command and liaison detachments with the same current tactical SIGINT estimate of the battlefield.

The EW CCIS is equipped with tools for EW mission planning, SIGINT tasking, asset deployment, sensor coverage analysis, ECM tasking, administration, and supply reporting. It has the ability to automatically plot EW asset positions on the map from Location Reports (LOCREPs). As all CCIS workstations provide the same functions and database information, the squadron can be commanded from any EWCC or EWLO detachment.

The EW CCIS also has the ability to translate TACREPs into formats compatible with the Advanced Concept Tactical Information Fusion (ACTIF) system produced by Defence Research Establishment Valcartier (DREV) for the Division and Brigade Intelligence Collection and Analysis Centre (ICAC)[4]. The ACTIF format TACREPs are transmitted from the EWCC to the ICAC over an Ethernet LAN. The ACTIF system then processes, stores, and displays the EW assessments on the ICAC analyst's map. The EW intelligence data is then fused with other reports to produce the ICAC's all-source intelligence estimate of the battlefield situation.

The EW CCIS has been successfully trialed with the EW squadron during ABCA Exercise Northern Lights at CFB Kingston in June 1994 and CF Exercise Rite-Complex at CFB

Valcartier in May 1995. Both were command post exercises that did not field actual sensors or troops. Exercise Rite-Complex was aimed at practising the command and control processes required to operate the Canadian Division on the battlefield in preparation for CF Exercise RV `95. EW CCIS workstations were deployed at the EWCC and EWLO detachments and operated as described above, with the EWCC feeding tactical SIGINT to ACTIF over a LAN. Since the actual unit assets were not deployed, an EW CCIS workstation was used at the EWOC exercise control cell to produce TACREP and EW Summary reports as dictated by the game play. These reports were transmitted over CNR to the EWCC and EWLO detachments, where they were received, parsed, correlated into the SIGINT database and automatically displayed on the EWCC and EWLO maps. The EWCC had the responsibility of releasing this data to the ACTIF in the ICAC over the LAN. The success of the EW CCIS workstations at these exercises demonstrated the impact of automation on the command and control process of the EW squadron.

The automation of the complete Intelligence/EW analysis process was demonstrated during the DREO/DREV Exercise Katimavik `95 at CFB Kingston in June 1995. This exercise was hosted by 2 EW Squadron in the 1 CDHSR compound, with the setup shown in Figure 7. The EW squadron provided the complete CEWOC system, an EWCC, and the personnel required to operate these detachments for the one week exercise. DREV provided a complete
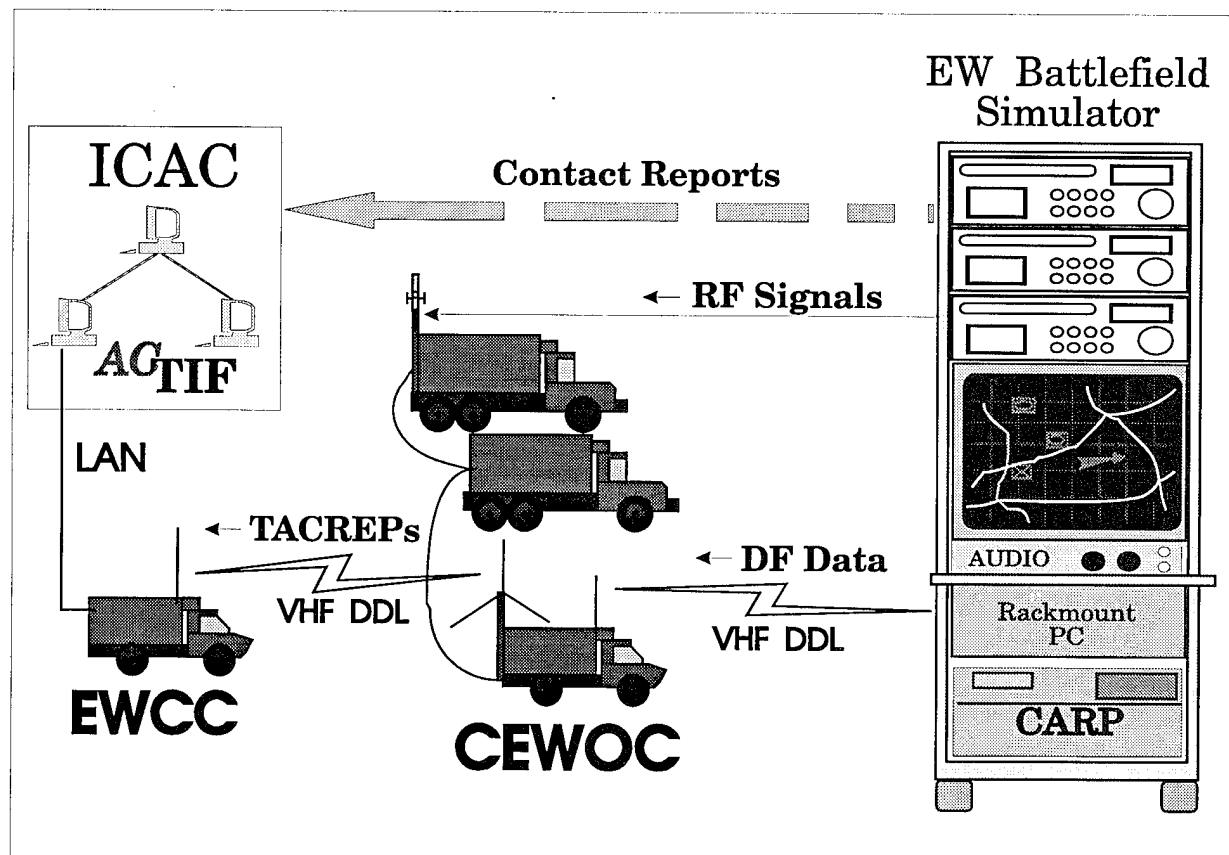

Figure 7 Exercise Katimavik `95 with 2 EW Squadron and 1 Int Company.

ACTIF system and the ICAC intelligence analysts were provided by 1 Int Company and 2 Int Platoon. The aim of the exercise was to study the effects of automation on the entire EW and Intelligence collection and analysis process using DFACTT and ACTIF in a controlled, but realistic, environment. This environment was provided by the EW Battlefield Simulator which is described in the following section. The Katimavik trial exercised the collection of data from simulated DF sensors, the intercept of simulated radio traffic by the TCAS, the data fusion and situation assessment process of the EW analysts, reporting of tactical SIGINT to the EWCC over CNR, passage of that intelligence to the Division ICAC using ACTIF, and the fusion with other sources of intelligence, such as contact reports provided by the Simulator, into the overall battlefield assessment.

These exercises have demonstrated the effects of basic automation on the Intelligence and Electronic Warfare (IEW) command and control process. The use of computers to gather, store, display, process, and report intelligence data makes the IEW collection process simpler, faster, and more reliable. It is now possible, using DFACTT deployed with the EW squadron and ACTIF with the ICAC, to electronically provide the Division and Brigade Commanders with an up-to-the-minute intelligence estimate of the battlefield situation.

3.6 EW Battlefield Simulator

The EW Battlefield Simulator consists of a graphical map-based workstation equipped with multiple Radio Frequency (RF) signal generators, a Computerized Audio Record and Playback (CARP) system, and multiple data communication suites for interfacing to the DFACTT and CEWOC systems[5]. The simulator is capable of creating, editing, and storing multiple exercises. The simulator provides a scoring facility to train and/or evaluate EW personnel and systems for each exercise. It provides tools for creating simulated models of various EW sensors, such as communications Direction-Finding sensors. These simulated sensors are able to model any realistic system including Probability Of Intercept (POI), sensitivity, range, etc. The simulated sensors are controlled from the EW System under test (DFACTT or CEWOC) for tasking, reporting, deployment, etc. The simulator can also create and realistically model land-based radio communications systems.

The EW Battlefield Simulator can be used to develop the Electronic Order of Battle (EOB) for any Potential Opposing Forces (POF) for use in multiple scenarios. Scenarios are created by users using the map-based GUI and POF EOB databases. Scenarios can be created for any area in the world, requiring only ADRG raster map data and Digital Terrain Evaluation Data (DTED) for the area of interest. The system will realistically and accurately calculate the Line Of Sight (LOS) and Radio Propagation Path Loss (RPPL) for simulated radio transmissions using DTED and smooth earth models. The LOS and RPPL are calculated during scenario execution from each transmitting unit to each sensor asset. This is used with the simulated unit's communication equipment parameters to determine the received signal strength at all sensors and each sensor's detection probability, accuracy, etc. The result is a realistic electronic battlefield

environment surrounding the Intelligence and EW units.

The simulator is a critical tool in the evaluation of personnel using automated systems as part of the IEW command and control process. It has proved invaluable for squadron training, such as Exercise Katimavik. The EW Battlefield Simulator will continue to be developed along with DFACTT and will be used to test new EW analysis algorithms in DFACTT at DREO. It will also be used with the EW squadron to practice, and experiment with, the EW command and control process.

4. SUMMARY

The knowledge gained through DFACTT has been incorporated by DLR into the SOR for the EW Control and Analysis Centre (EWCAC) to be fielded with the EW squadron by 1998 under project L2066. Future research includes the fusion of new ESM sensor data, the use of knowledge-based systems to provide advanced analysis and decision aids, and further automation of the command and control process. The DFACTT and EW Battlefield Simulator will form the basis of an EW Automation ADM for Land Tactical EW Equipment Project L1246. This ADM will be used to produce an advanced EWCAC in the 2005 time-frame.

DFACTT has already automated the command and control process of the Land Force EW squadron. This was achieved by producing a fully functional CCIS and EW analysis system through close end-user involvement in an iterative development process. Current DFACTT functionality represents the composite input of over one hundred Canadian Forces personnel. The operation of each DFACTT component has been tailored to the specialized equipment and doctrine of the Land Force EW squadron. It has also begun to address the effects of automation on the command and control process of the EW squadron. The continued success of this project will not be possible without the ongoing cooperation, support, and participation of the EW squadron and the Land Force EW community.

5. ACKNOWLEDGMENTS

6. REFERENCES

[1].   J. Hooper and D. Elsaesser, "Data Fusion And Correlation Techniques Testbed (DFACTT): RV '92 Trial Report", DREO Report No. 1177, July 1993.

[2].   J. Hooper and D. Elsaesser, "Communications Electronic Warfare Data Fusion And Correlation Techniques Testbed (DFACTT): System Functional and Technical Specification", DREO Technical Note 90-24, November 1990.

[3].   Steve McClure, "Object Tools - Smalltalk Market Accelerates", International Data Corporation, IDC #9818, Framingham, MA, March 1995.

[4].   M. Gauvin, S. Lapointe and M. Lizotte, "Tactical Information Fusion Prototype: Evaluation Through an Abbreviated Command Post Exercise ", DREV-R-9503, September 1995.

[5].   Edward George and Derek Elsaesser, "A Land Electronic Warfare Battlefield Simulator", Presentation and Conference Proceedings, Canadian Defence Preparedness Association Conference on Training and Simulation '94, 4 October 1994.

LIST OF ACRONYMS

1 CDHSR	1st Canadian Division Headquarters and Signal Regiment
A/D/A	Analog/Digital/Analog
ABCA	American, British, Canadian, Australian
ACTIF	Advanced Concept Tactical Information Fusion system
ADM	Advanced Development Model
ADRG	ARC Digital Raster Graphics
AMEP	Advanced Modular ESM Processor
API	Application Program Interface
bps	bits per second
C^2	Command and Control
C^2IS	Command and Control Information System
CARP	Computerized Audio Record Playback
CCIS	Command and Control Information System
CEP	Circular Error Probability
CEWOC	Computerized Electronic Warfare Operation Centre
CF	Canadian Forces
CFB	Canadian Forces Base
CNR	Combat Net Radio
COE	Common Operating Environment
CRAD	Chief Research And Development
D Geo Ops	Director Geographic Operations (J2 Geomatics)
DF	Direction Finding
DFACTT	Data Fusion And Correlation Techniques Testbed
DLR	Director Land Requirements
DO	Duty Officer
DREO	Defence Research Establishment Ottawa
DREV	Defence Research Establishment Valcartier
DTED	Digital Terrain Elevation Data
E-mail	Electronic mail
EOB	Electronic Order Of Battle
ESM	Electronic Support Measures
EW	Electronic Warfare
EWCAC	EW Control and Analysis Centre
EWCC	EW Coordination Centre
EWLO	EW Liaison Officer
EWOC	Electronic Warfare Operation Centre
FRS	Functional Requirements Specification
GIS	Geographic Information System
GUI	Graphical User Interface

HF	High Frequency
HFE	Human Factors Engineering
ICAC	Intelligence Collection and Analysis Centre
IEW	Intelligence and Electronic Warfare
Int	Intelligence
LAN	Local Area Network
LEWAS	Land EW Automation and Sensors
LOCREP	Location Report
LOS	Line Of Sight
LTEWI	Land Tactical Electronic Warfare Improvement
MICCI	MANTIS Integrated Communications and Control Interface
NATO	North Atlantic Treaty Organization
ORBAT	Order Of Battle
OS	Operating System
OTI	Object Technology International Inc.
POF	Potential Opposing Forces
POI	Probability Of Intercept
RASP	Rapid Acquisition Spectral Processor
RF	Radio Frequency
RPPL	Radio Propagation Path Loss
SIGINT	Signals Intelligence
SIS	Search Intercept Supervisor
SKL	Software Kinetics Limited
SOR	Statement of Operational Requirements
TACREP	Tactical Report
TCAS	Tactical Communications Analysis System
UHF	Ultra High Frequency
UTM	Universal Transverse Mercator
VHF	Very High Frequency

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(U)   Electronic Warfare is a land combat function. To be effective on the modern battlefield, Land EW requires an integrated Command and Control Information System (CCIS). The EW CCIS must automate the tasking of EW assets, sensor data collection, and reporting of threat warnings and tactical Signals Intelligence (SIGINT) to the battlefield commander. Automation of the command and control function has changed the Electronic Warfare process, resulting in a continuously evolving EW CCIS requirement specific to the Canadian Forces. The Data Fusion and Correlation Techniques Testbed (DFACTT) is being developed at Defence Research Establishment Ottawa using an evolutionary prototyping approach to determine and define the CCIS and tactical SIGINT analysis requirements of the Land Force's EW Squadron. This report describes the status of the DFACTT project as of September 1995.

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